Acknowledgments

The support from the Kraft Foods Company and the National Dairy Products Corporation for this investigation is hereby acknowledged. We should also like to thank Louis Gennuso and Stan Mikszta for preparing the oil samples used in these experiments.

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[Received March 26, 1959]

Fatty Acid Composition of Several Varieties of Soybeans[1]

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LITTLE INFORMATION has been published on the effects of different crop years and widely spaced geographic locations on the percentage of fatty acids in soybean oil. Fatty acid composition of soybean oil for 13 varieties was reported by Alderks (1) and for a single variety by Simmons and Quackenbush (8). Several others also have reported fatty acid data based on single or composite samples.

Such studies do not indicate the wide range of seasonal and locational variability which occurs. The study by Howell and Collins (5) showed that environmental variability, particularly differences in temperature at the time of seed development, caused major differences in linolenic and linoleic acid contents. In fact, differences associated with temperature were of greater magnitude than those associated with varieties.

To provide more complete information on the variability in fatty acid composition of soybean oil, the present study was done on seed produced in 1956 and 1957 at 43 locations in 18 states.

Experimental

Soybean seed from Uniform Test Groups I, III, IV, and VII of the U. S. Regional Soybean Laboratory conducted at six to 14 locations were used in this study. Figure 1 (7) shows the approximate area of the United States where each Uniform Test Group is grown.

In 1956 oil was analyzed from the seeds produced by Groups I, III, and IV in each of four replications of each variety at each location and from three replications of Group VII. Analyses of the 1957 oil were made on duplicate samples of seed from selected locations in common with the 1956 tests. Oil was extracted by the official A.O.C.S. method (2), and immediately after extraction fatty acids in the crude oil were determined by the method of Collins and Sedgwick (4). Percentages of fatty acids are reported on a crude oil basis. The iodine values of the crude oil which were used in calculating percentages of oleic and saturated portions were obtained from the refractive index of the oil by the method of Majors and Milner (6).

The percentage values for saturated acids are higher than actual values because glycerol and some of the refining loss products in crude soybean oil were classed as saturated acids.

Standard analysis of variance techniques of Snedecor (9) were used in the interpretation of the significance of the data.

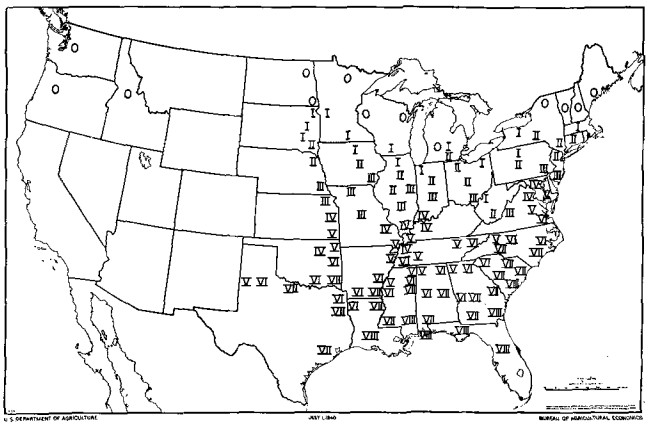

FIG. 1. Areas in the United States where soybean varieties in each of the maturity-classification groups are adapted as full-season crops.

Results

Data for the five varieties in Group I are summarized in Table I. Figure 2 shows the variability in composition of Chippewa soybean oil at 12 and nine locations in 1956 and 1957, respectively. Chippewa oil, in common with Blackhawk, Grant, and Mandarin (Ottawa), contained about 8.5% linolenic acid while Monroe had about 9.5%. Blackhawk tended to be lowest in both years in average percentage of linolenic acid (8.39%) at all locations, and Monroe averaged highest (9.40%). Chippewa oil was highest in the percentage of linoleic acid (50.8%).

Data for oils of six varieties in Group III are summarized in Table II. Figure 3 shows the variability in composition of Lincoln soybean oil for 11 locations in 1956 and eight in 1957. The mean percentages of linolenic and linoleic acids in Lincoln were similar for both crop years. In 1956 for Lincoln the ranges (not shown in the table) of linolenic, 7.70% to 8.98%, and linoleic, 49.1% to 52.9%, were similar to those for Chippewa in Group I, which had linolenic 7.75% to 9.62%, and linoleic 48.6% to 52.8%. Clark, Lincoln, and Shelby, three closely related varieties, con-

[1] Publication No. 326 of the U. S. Regional Soybean Laboratory, Urbana, Ill.

TABLE I

Fatty Acid Composition and Iodine Numbers for Oil of Five Soybean Varieties in Uniform Test, Group I, 1956 [a] and 1957 [b]

Variety	Linolenic acid		Linoleic acid		Oleic acid		Saturated acid [c]		Iodine number	
	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957
	%	%	%	%	%	%	%	%		
Blackhawk	8.19	8.58	47.0	47.1	24.8	24.6	20.0	19.7	129.9	130.9
Chippewa	8.46	8.53	50.5	51.2	22.2	21.0	18.9	19.1	134.7	135.2
Grant	8.53	.....	49.2	.....	23.0	.....	19.5	.....	132.6	.....
Mandarin (Ottawa)	8.37	8.46	45.9	47.2	26.4	25.0	19.3	19.2	129.7	131.2
Monroe	9.35	9.45	47.5	48.0	23.3	22.9	19.9	19.6	132.5	133.4
Mean	8.58	8.76	48.0	48.4	23.7	23.4	19.5	19.4	131.9	132.7
Standard error for variety means	.10	.09	.18	.20	.29	.32	.16	.28		

[a] Mean of 12 locations.
[b] Mean of 9 locations.
[c] Contains some glycerol and other materials.

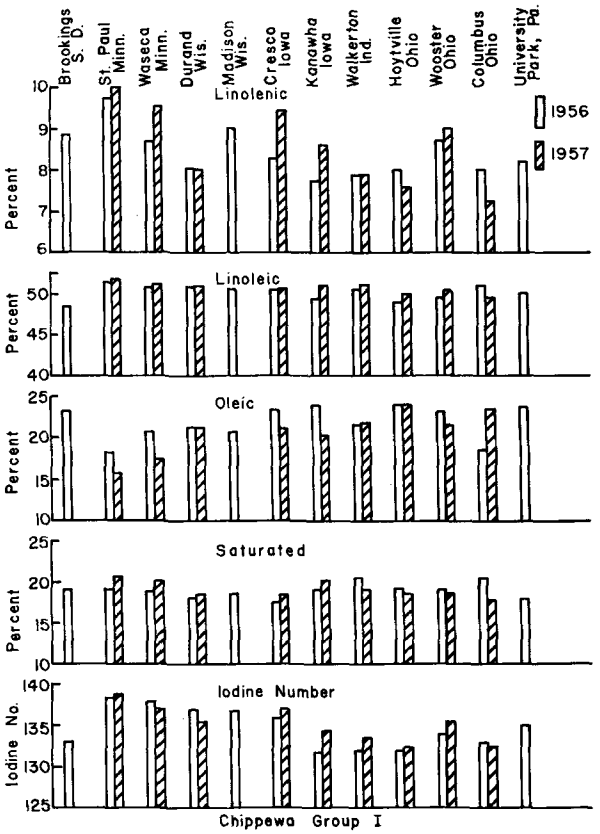

FIG. 2. Fatty acid composition and iodine number of oil from Chippewa soybeans grown at different locations, 1956–57.

tained similar percentages of linolenic and linoleic acids.

Data for the five varieties in Group IV are summarized in Table III. Figure 4 shows the variability in composition of Clark oil (within its proper group) grown at six locations in 1956 and two locations in 1957. Clark was included also in Group III for easy comparison of Group III and IV varieties. Clark oil was of similar composition in both Uniform Test Groups III and IV. Among Group IV varieties in both years C1068 averaged highest (8.66% linolenic) while Perry oil averaged lowest (7.56% linolenic) at all locations.

Data for the three varieties in Group VII are summarized in Table IV. Figure 5 shows the fatty acid composition of Roanoke oil for 14 and five locations in 1956 and 1957, respectively.

Jackson and Roanoke oils in both years were consistently well above 50% in linoleic acid content and averaged about 2 percentage points higher than oil from Lee. They were also higher than Lee in linolenic acid and in iodine number of the oil.

Discussion

In the two crop years of this study, soybean oil of currently important varieties ranged about 5% to 11% in linolenic, 43% to 56% in linoleic, 15% to 33% in oleic, and 11% to 26% in saturated acids. Similar wide ranges of locational and varietal differences in fatty acid composition of the oil were found in both years.

Since the study of the 1956 crop was done on replicated samples from more locations than were tested in 1957, the discussion will deal mainly with the 1956 crop.

Analyses of variance (9) for the data were made for each crop year. In general, differences for all fatty acids were highly significant (1% level) for varieties and locations in Groups I, III, and VII for both crop years. Oils of Group IV varieties were less variable, and location differences were not significant;

TABLE II

Fatty Acid Composition and Iodine Numbers for Oil of Six Soybean Varieties in Uniform Test, Group III, 1956 [a] and 1957 [b]

Variety	Linolenic acid		Linoleic acid		Oleic acid		Saturated acid [c]		Iodine number	
	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957
	%	%	%	%	%	%	%	%		
Clark	8.04	8.13	51.4	50.8	21.3	21.4	19.3	19.2	134.2	133.5
Dunfield	7.35	7.78	46.0	46.4	26.7	26.7	19.1	19.1	128.2	128.8
Illini	8.29	.....	48.9	.....	24.0	.....	18.8	.....	132.8	.....
Lincoln	8.29	8.70	50.9	50.8	22.1	21.1	18.8	19.5	134.6	134.6
Ford	7.25	7.89	48.0	49.0	25.4	22.5	19.3	20.7	129.6	130.5
Shelby	8.01	8.19	50.3	49.4	22.0	22.4	19.8	20.0	132.6	131.9
Mean	7.87	8.14	49.3	49.3	23.6	22.8	19.2	19.7	132.0	131.9
Standard error for variety means	.05	.11	.23	.41	.35	.89	.17	.63		

[a] Mean of 11 locations.
[b] Mean of 8 locations.
[c] Contains some glycerol and other materials.

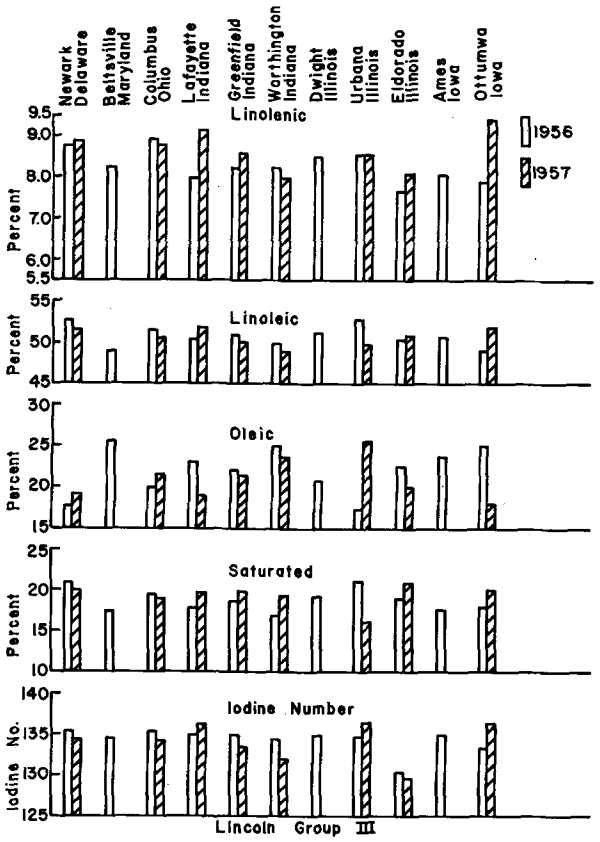

FIG. 3. Fatty acid composition and iodine number of oil from Lincoln soybeans grown at different locations, 1956–57.

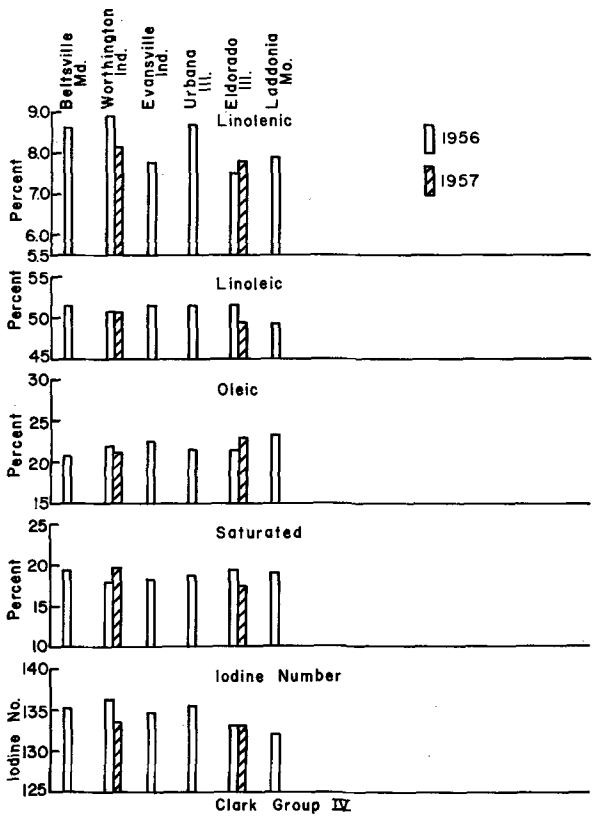

FIG. 4. Fatty acid composition and iodine number of oil from Clark soybeans grown at different locations, 1956–57.

however varieties were highly significantly different in linolenic and linoleic acids. Replication differences within locations were significant but of slight importance in comparison with the major differences found in varieties and locations. Differences in analyses of duplicate samples were not significant.

Oil of Uniform Test Group I, varieties (1956), averaged highest in linolenic of these four groups (8.58%) but was lowest of the groups in linoleic (48%). Group VII varieties averaged lowest in linolenic (7.24%) but were highest in linoleic (51.2%). Varieties of these two groups differed markedly in percentage of linoleic acid in their oil. Within each group varieties tended to maintain the same relative order of fatty acid compositions of oil at all locations in the two years of this study. In general, soybean varieties, when grown near the northern range of their area of adaptation, produced oil which was 1 to 2 percentage points higher in linolenic and 3 to 6 higher in linoleic than when grown at the southern range of their adaptation.

Differences in daily temperatures (10) in 1956 and 1957, with generally cooler weather in 1957, could easily account for the consistently higher percentages of linolenic and linoleic acid in soybean oil at many locations in 1957 as Collins and Howell (3) have shown a close negative correlation between these acids and the temperature during oil formation in the seed.

Howell and Collins (5), in a study of Lincoln soybeans grown under controlled temperatures, found that oil produced at 70°F. contained 10.5% linolenic acid; at 77°, 8.2%; and at 85°, 6.8%. The same authors reported Midwest soybeans, which were grown in 12-hr. photoperiods at 70°, 80°, and 90°, contained 16.1%, 9.4%, and 5.3% linolenic acid, respectively, for these temperatures. Daily temperatures, which were about 10° higher in 1956 than in 1957 (10),

TABLE III

Fatty Acid Composition and Iodine Numbers for Oil of Five Soybean Varieties in Uniform Test, Group IV, 1956 [a] and 1957 [b]

Variety	Linolenic acid		Linoleic acid		Oleic acid		Saturated acid [c]		Iodine number	
	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957
	%	%	%	%	%	%	%	%		
Chief	8.44	8.46	48.5	47.6	23.8	28.9	19.3	15.1	132.4	135.3
Clark	8.18	7.97	51.0	50.0	21.9	23.3	18.9	18.7	134.5	133.4
Perry	7.66	7.46	48.0	46.4	24.9	26.5	19.6	19.7	130.2	128.2
Wabash	7.82	7.68	47.0	45.0	25.9	29.3	19.4	18.2	129.7	127.9
C1068	8.60	8.72	51.2	50.0	23.1	24.5	17.2	17.0	137.0	136.3
Mean	8.14	8.06	49.1	47.8	23.9	26.5	18.9	17.7	132.8	132.2
Standard error for variety means	.08	.20	.22	.64	.47	2.59	.26	1.96		

[a] Mean of 6 locations.
[b] Mean of 2 locations.
[c] Contains some glycerol and other materials.

TABLE IV

Fatty Acid Composition and Iodine Numbers for Oil of Three Soybean Varieties in Uniform Test, Group VII, 1956 [a] and 1957 [b]

Variety	Linolenic acid		Linoleic acid		Oleic acid		Saturated acid [c]		Iodine number	
	1956	1957	1956	1957	1956	1957	1956	1957	1956	1957
	%	%	%	%	%	%	%	%		
Jackson	7.52	8.08	52.2	54.9	20.4	18.8	19.8	18.3	133.4	138.1
Roanoke	7.46	8.49	51.9	54.7	21.8	18.2	18.8	18.7	134.1	138.0
Lee	6.73	7.48	49.5	52.5	26.6	21.1	17.3	18.9	131.9	134.7
Mean	7.24	8.02	51.2	54.0	22.9	19.4	18.6	18.6	133.1	136.9
Standard error for variety means	.08	.10	.29	.63	.98	.93	.77	.43		

[a] Mean of 14 locations.
[b] Mean of 5 locations.
[c] Contains some glycerol and other materials.

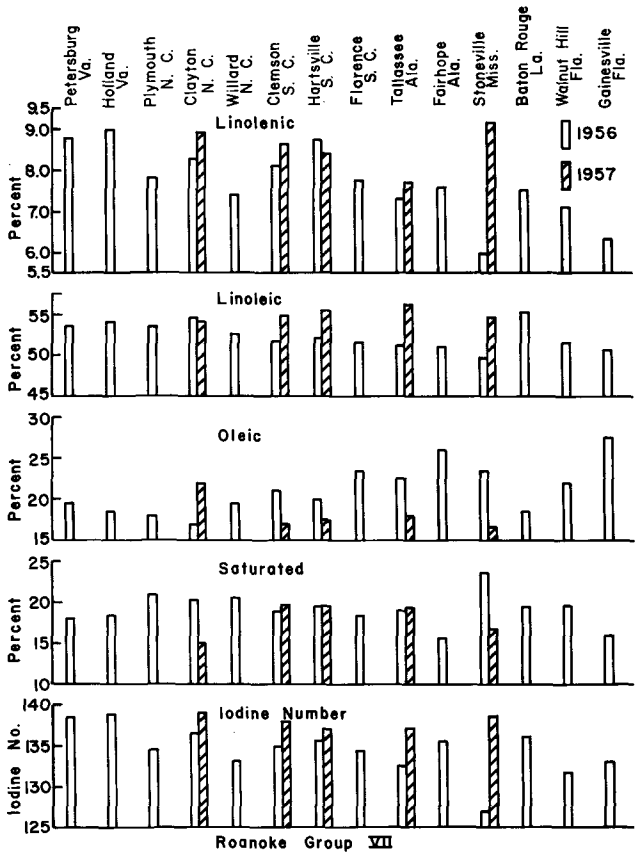

FIG. 5. Fatty acid composition and iodine number of oil from Roanoke soybeans grown at different locations, 1956–57.

prevailed at Ottumwa, Ia., during the critical period of fatty acid formation in seed filling.

These differences in temperature undoubtedly account for oil of Roanoke with 5.93% and 9.15% linolenic acid at Stoneville, and of Lincoln with 7.93% and 9.43% linolenic acid at Ottumwa in these two seasons.

Summary

Fatty acid composition of soybean oil of 18 currently important varieties from 43 locations in 16 states of the United States ranged from about 5% to 11% in linolenic, 43% to 56% in linoleic, 15% to 33% in oleic, and 11% to 26% in saturated acids. Oil of all 18 varieties had wide ranges in composition at different locations in two crop years. Within each group varieties tended to maintain the same relative order of fatty acid compositions of oil at all locations in the two years of this study.

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[Received May 29, 1959]

A Comparison of Six Solvents for the Extraction of Jojoba Seed

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A PLANT, native to the desert areas of Southwestern United States, offers excellent possibilities as a potential crop since it would not compete with such oils as cottonseed, soybean, or linseed but would diversify American agriculture by giving this country a new industrial raw material in an area in which production is at present practically nonexistent.

Simmondsia chinensis, commonly known as jojoba, is unique in that its seed contain almost 50% of a liquid wax which appears to be a source of many chemical compounds of great interest in many applications (6). The residual meal, after the extraction of the wax, can apparently be utilized in animal feeds (12).

Research is at present being carried on by the Department of Agriculture along two major lines

[1] One of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.